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Are Barbados Crime Rate Fluctuations Transitory or Permanent?

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Abstract

Using a model selection framework, this exploratory paper attempts to answer the fundamental question of whether Barbados crime rate fluctuations are transitory or permanent. Although not clear-cut, Barbados crime rate series follows a trend-stationary process. It means that in Barbados an unexpected change in the crime rate should not substantially alter one's forecast of the latter in the long run. Put differently, in the long run the crime rate in Barbados should return to its natural rate.

Keywords: crime, model selection, structural break, stationarity, Barbados.

1. Introduction

Nowadays, crime has become a plague in many societies. For sure, crime at large is present in every society although at various rates. Crime is a nuisance for the affected societies or parties to the extent that it is generally associated with costs that usually reflect economic loss[1], health distress or loss and social distress. These losses or distresses justify to a great extent any study on crime.

This study examines the time series properties of the crime rate in Barbados for the period 1970-2006. The research question of interest is the following: are Barbados crime rate fluctuations transitory or permanent? That is, are the crime rate fluctuations in Barbados characterized by a deterministic trend or a stochastic trend?

To repeat, the study does neither develop a theory of crimes nor target the determinants of crimes. Definitely, it is not about crime policy. Rather, it is about extracting some information from the univariate time series called crime rate.

A regression model selection framework is the methodological tool used to answer the research question. Indeed, contrary to the bulk of authors dealing with the same concern, this paper relies on model selection rather than on formal unit root tests to deal with the research question. In addition, a particular attention is given to the issue of "break" in the crime rate series as any significant break in the series, if not taken into account, can be a source of non-stationarity/stationarity.

Barbados is a small Caribbean island with a population of about 275,000 in the year 2006 and a population density of about 646 persons per square kilometer making it a very densely populated country. Barbados stands good in terms of its overall economic and social achievements. This has been substantiated over the years by the high human development rank constantly occupied by the country in the context of the UN Human Development Index (HDI). Tourism has the leading position in this notable development. In the period 1970-2006, tourist arrivals increased by 259.7%. Barbados is also known as a country with a "low "crime rate by the world standard[2]". According to the statistics of Interpol (2004), Barbados had a murder rate of 7.47 per 100,000 persons compared to 1.10 for Japan and 5.5 for the USA in 2000. The rape rate

[1] In 1996 Freeman estimated "that the cost of crime in the United States may have been around 4 percent of gross domestic product in the early 1990s." (Becsi, 1999, 41).

[2] "Low" with respect to the world standard may not necessarily be so with respect to a given nation's standard. That is how low is "low' may reveal to be very relative.

stood at 25.38 compared to 4.08 for Japan and 32.05 for the USA. The overall crime rate (per 100,000 persons) was 2,364.94 compared to 1,709.88 for Japan and 4,123.97 for the USA. In recent years, the crime rate in Barbados has been decreasing. For example, in the period 2002-2006, the total crimes decreased by 22% and the property crimes by 31%.

The study is important for at least two reasons. First, Barbados as a case study is interesting in its own right. Indeed, while Barbados remains by the world standard a low crime spot there is a perception of change in the trend of crime confirming the adage that one can't rest on his laurels. Second, the examination of the research question has a far reaching effect on the forecast of the future crime rate in Barbados. To recall, under a deterministic trend, a shock to crime rate innovation will exhibit a trend reversion, will have a temporary effect on crime rate, will not change the long-term forecasts of crime rate and will be characterized by a bounded forecast error variance. In plain English, a trend-stationary crime rate means that the crime rates in different decades are not connected except via the deterministic trend. In other words, in the long run the country's crime rate should return to its natural rate (see, in another context, Campbell & Mankiw 1987, 857). On the contrary, under a stochastic trend, a shock to crime rate innovation will have an ever lasting effect (permanent or persistent) on crime rate, will alter the long-term forecasts of crime rate and will be characterized by unbounded forecast errors (see, among others, Stewart 2005, 746-754; Newbold *et al*. 2000, 108-109). That is, under a difference-stationary process, actual crime rate largely reflect past crime rate.

At the methodological level, this study builds on the work by Campbell & Mankiw (1987) as well as Newbold *et al.* (2000). The two groups of authors emphasized model selection of ARIMA processes in dealing with the issue of trend stationarity versus trend randomness in the univariate series such as output and real agricultural produce prices. In terms of crime literature, I acknowledge among others the work by Sridharan *et al*. (2003) who used an intervention analysis through a structural time series to deal with the impact of event (intervention) on the evolution of crime rate as well as Sookram *et al*. (2010) who exploited time-series data from Trinidad and Tobago to test for a long-run relationship among different variables including serious crime.

The study makes the following contributions to the literature on crime. First, although quite a number of studies have dealt with the issue of crime in the Caribbean (e.g., Allen & Boxill 2003; Harriott 2002 and 2003; King 2003; Fost & Bennet 1998), only a handful has focused on crime in Barbados (Yeboah 2002; Warner & Greenidge 2001; de Albuquerque & McElroy 1999; and a series of survey reports from the National Task force on Crime Prevention in Barbados including Nuttall *et al*. 2003). This is a useful add-on to the Barbadian case. Second, this is one of the few studies which squarely focus on a univariate crime rate series; most studies have a multivariate focus. Third, this is also a rare study on crime which pays particular attention to the existence of break(s) in the crime rate series, break which usually affects the nature of the trend in a time series.

The paper is organized as follows. Section 2 deals with the basic statistical information derived from the data. Section 3 develops the methodological tool to answer the research question as well as deals with the estimation results and their interpretations. Section 4 contains concluding remarks.

2. Data: Primary Statistical Information

What useful statistical information can one extract from a casual observation of the data? To answer this question, I resort to graphs and summary statistics. Before proceeding, some explanations are warranted for the derivation of yearly resident equivalent of tourist population (long stay and cruise). To this end, I use the popular methodology exploited among others by de Albuquerque & McElroy (1997, 975-976). The resident equivalent of tourist population (*RPOP*) is given by

$$RPOP = \frac{\text{(Long stay x average length of stay + cruise x 1)}}{365}$$

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The converted tourist population added to local population gives rise to total population. The latter statistic helps derive the number of crimes per 100,000 individuals, also known as the crime rate.

Table 1: Basic Statistics for Barbados: Crime and Population,1970-2006

	GCR	**CR**	**TPOP**	**POP**	**RPOP**
Mean	9001.351	3248.100	274732.7	266119.7	8613.002
Median	8769.000	3074.568	276078.0	266994.0	9043.388
Maximum	13047.00	4569.023	305195.7	292930.0	12644.77
Minimum	5868.000	2299.623	241241.4	238752.0	2489.439
Std. Dev.	2178.514	628.6722	20267.26	17977.11	2642.856
Skewness	0.209902	0.546083	-0.033104	-0.013191	-0.458332
Kurtosis	1.859732	2.419189	1.622614	1.516674	2.487067
Jarque-Bera	2.276190	2.359013	2.931594	3.393136	1.701037
Probability	0.320429	0.307430	0.230894	0.183312	0.427193

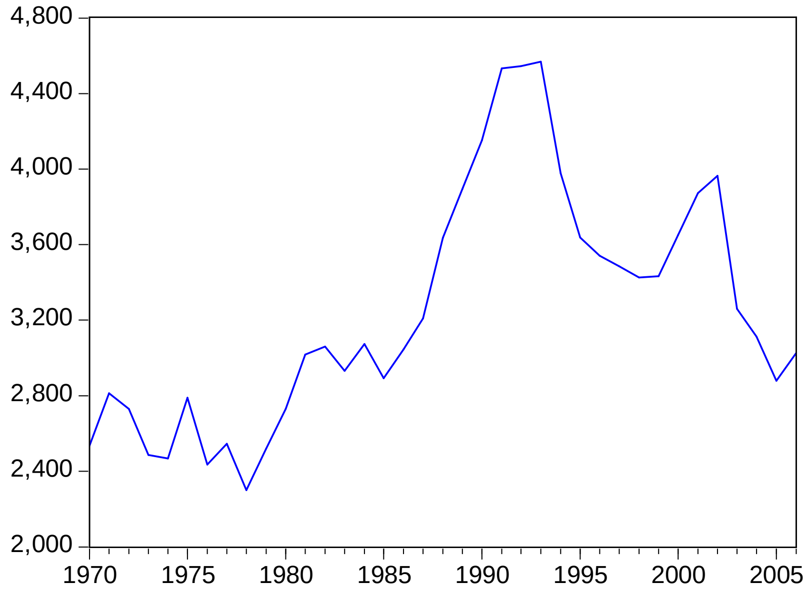
Source: Annual Statistical Digest, Central Bank of Barbados, 2006, 2001; Economic and Financial Statistics, Central Bank of Barbados, August 2007; Royal Barbados Police Force and IMF database.

Note: GCR: total crimes: crimes against the person+ crimes against the property+ other crimes including drug crimes; CR: crime rate or total crimes per 100,000 persons; POP stands for local population; RPOP is yearly resident equivalent of tourist (long stay and cruise) population; TPO stands for the sum of local and tourist population.

Table 1 contains the summary statistics of crime and population variables. It reveals that the average yearly population in the period 1970-2006 was of 274,733 persons, the total average yearly crime stood at 9,001 and the average yearly crime rate (per 100,000 persons) reached 3,248. That is, 1 crime has been on average committed against every 31 persons. Total crime and crime rate peaked in 1993 with 13,047 crimes and 4,569 crimes, respectively. The year with the least crimes was 1978 with 5,868 and 2,299 for total crime and crime rate, respectively. Each variable in the table seems to be normally distributed according to the Jarque Bera (JB) test statistic. However, this conclusion is to be taken with caution as the JB statistic, which is asymptotically distributed as a chi-squared, does not perform well in finite samples.

Fig1 deals with the evolution of Barbados crime rate (CR). A casual observation indicates that the series does not wander forever as the mean of the series (3,248 crimes) is crossed twice. The series also seems to be characterized by one major break which occurs in 1993. Overall, Fig. 1 seems to reveal the presence of a broken trend.

Fig.1.: Crime Rates in Barbados, 1970-2006



Of particular interest is the stationarity property of the series. To recall, in its simple form a stationary process is a mean reverting process. Stationarity is a significant concept for at least three reasons. First, most test statistics have been derived under the assumption of stationarity. Second, the lack of stationarity of a time series can give rise to nonsense results (e.g., nonsense or spurious regressions). Third, according to the Wold's theorem any stationary process can be decomposed into a deterministic component and a moving average of possibly infinite order (see Mamingi 2005, 160).

3. In Search of Trend-Stationarity and Difference-Stationarity.

The research question of interest is whether Barbados crime rate series can be characterized as a trend-stationary process or a difference-stationary process. Although in such a case, most authors will rely exclusively on tests for unit root/stationary tests to decide on the nature of the trend, I favour a pure model selection which focuses on the comparison of the two competing models in terms of inference on the parameters of interest. Indeed, as Newbold *et al*. (2000, 109-110) point out this approach is better than the unit root tests framework as the power of unit root tests with small or moderate sample sizes is low and also as in the context of unit root tests, any unit root model can always be approximated by a stationary model and vice versa.

Since the presence of a structural break or outlier can alter the nature of the trend, I introduce in the analysis the major break captured in Fig.1. At the outset, although the practice of considering the date of the break as known as in Perron (1989) has been severely criticized (see, for example, Christiano 1992; Zivot & Andrews 1992), I still use the decried approach since not using such an important prior may reveal suboptimal. That said, the 1993 break is introduced as follows:

$$D_t = 1 \;\; if \;\; t = T_b + 1, \;\; 0 \text{ otherwise}$$
$$TD_t = 1 \;\; if \;\; t > T_b, \;\; 0 \text{ otherwise}$$
$$DT_t = t - T_b \;\; if \;\; t > T_b, \;\; 0 \text{ otherwise}$$
$$DL_t = t \;\; if \;\; t > T_b, \;\; 0 \text{ otherwise}$$

where T_b is the 1993 break, $1 < T_b < T$.

Thus, the following models are of interest for the unit root hypothesis:

$$CR_t = c + d_1 D_t + CR_{t-1} + u_t \tag{1}$$
$$CR_t = a + d_2 TD_t + CR_{t-1} + u_t \tag{2}$$
$$CR_t = a + d_1 D_t + d_2 TD_t + CR_{t-1} + u_t \tag{3}$$

where *CR* stands for crime rate, $u_t \sim ARMA(p,q)$ and other variables are defined as above.

In addition, the following models are appropriate for the stationary hypothesis:

$$CR_t = a + d_2 TD_t + \delta_1 trend + u_t \tag{4}$$
$$CR_t = c + d_3 DT_t + \delta_1 trend + u_t \tag{5}$$
$$CR_t = a + d_2 TD_t + d_4 DL_t + \delta_1 trend + u_t \tag{6}$$

where $u_t \sim ARMA(p,q)$. $\delta_2 CR_{t-1}$ with $|\delta_2| < 1$ can be added to the above equations.

To recall, Eq. (1) and Eq. (4) deal with change in the level and change in the intercept $(a + d_2)$, respectively; Eq. (2) and Eq. (5) are concerned with change in the drift and change in the slope $(d_3 + \delta_1)$, respectively and Eq. (3) and Eq. (6) include both corresponding changes.

Table 2 reports the results of Eq. (3), the best model of he batch (1) –(3). The results indicate that the 1993 break affects the level and the slope. Barbados crime rate series follows a non-stationary process since the coefficient of the lagged crime rate is 1.05.

Table 3: The Non-Stationary Model with Break: Model (3) Results.

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Dependent Variable: CR_t

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-45.34882	134.4499	-0.337292	0.7382
D_t	-357.5189	117.0841	-3.053521	0.0046
DT_t	-202.8967	39.80813	-5.096866	0.0000
CR_{t-1}	1.048465	0.042440	24.70478	0.0000
MA(3)	-0.965857	0.027655	-34.92522	0.0000

R-squared	0.928323	Mean dependent var	3267.891
Adjusted R-squared	0.919074	S.D. dependent var	625.7915
S.E. of regression	178.0220	Akaike info criterion	13.32994
Sum squared resid	982447.0	Schwarz criterion	13.54987
Log likelihood	-234.9389	F-statistic	100.3735
Durbin-Watson stat	2.232735	Prob(F-statistic)	0.000000

Note: variables are defined as in the text.

Table 3 presents the results of Eq. (6), the best model in the batch (4)-(6). As can be seen, the coefficients of the break are statistically significantly negative. The break affects both level and slope (growth rate). In addition, the coefficient of the trend is statistically significantly positive. The trend-stationary model is also a valid model. Note that adding the lagged crime rate to the model provides inferior results.

Since both models are equally valid I recourse to the model selection criteria to choose the better of the two. As pointed above, the criteria of interest are the *AIC* and the *SIC*. According to these criteria, the trend-stationary model with change in level and slope dominates the corresponding competing non-stationary model. Indeed, the *AIC* value for the trend-stationary model is smaller than that of the non-stationary model and so is the *SIC*.

Table 3: The Trend-Stationary Model with Level and Slope Changes:

Model (6) Results.

Dependent Variable: CR_t

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1078.830	381.2191	2.829947	0.0082
TD_t	-343.2794	123.5957	-2.777439	0.0094
DL_t	-212.7086	30.61809	-6.947155	0.0000
TREND	137.1902	19.47534	7.044304	0.0000
AR(1)	0.705514	0.125765	5.609792	0.0000
MA(3)	-0.970862	0.024900	-38.99039	0.0000

R-squared	0.944571	Mean dependent var	3267.891
Adjusted R-squared	0.935333	S.D. dependent var	625.7915
S.E. of regression	159.1365	Akaike info criterion	13.12841
Sum squared resid	759732.5	Schwarz criterion	13.39233
Log likelihood	-230.3114	F-statistic	102.2475
Durbin-Watson stat	2.060538	Prob(F-statistic)	0.000000

Note: variables are defined as in the text.

5. Conclusion

The objective of this exploratory study is to answer the question of whether the crime rate fluctuations in Barbados can be characterized as transitory or permanent. The study uses a model selection framework as the tool to discriminate between the two competing models. In addition, the study takes into account the break effect.

The results of the investigation indicate that the two competing models are close enough. Nevertheless, overall a slight edge is given to the trend-stationary model by virtue of the size of its SIC/AIC. That is, the study concludes that Barbados crime rate fluctuations are transitory. As implication, a shock to Barbados crime rate fluctuations will not last forever; in the long run the crime rate will return to its natural rate.

The paper can be revisited in several directions. First, the issue of the number of breaks in the crime rate series needs a more thorough analysis. Second, although not sure whether it will substantially alter the results found here, a break of unknown date can be used. Third, a fractional integration framework can also be of interest.

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